TTU Initiative to Evaluate and Improve Critical Thinking Skills
Third Year Report
May, 2003
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Since TTU's efforts to assess and improve critical thinking are strongly integrated the material below is being presented in sections 1b and 4b. Previous reviewers also requested that all information be included in each section.

Background

Tennessee Tech University began a pilot program during the 2000-2001 academic year to evaluate critical thinking skills of graduating seniors. During the 2000-2001 academic year approximately 200 seniors were given the "Tasks in Critical Thinking" Test developed by ETS. The students given the test were selected using a stratified random sample of seniors from four colleges at the University (education, arts & sciences, business, and engineering).

Tennessee Tech University selected the ETS test because it was an essay test and could involve faculty in the scoring and discussion of student responses. Such faculty involvement was seen as an essential ingredient in any subsequent efforts to encourage faculty to modify their teaching to improve critical thinking. Many faculty involved in the first scoring workshop gained insight into student deficiencies in critical thinking and discussed the need to modify their teaching approaches to provide students with more opportunities to develop critical thinking skills.

Three factors played an important role in our decision to stop using the ETS test and explore other means of evaluating critical thinking skills. Our statistical analysis of the test results and feedback from faculty involved in the scoring of the test raised serious questions about the validity of the test. Specifically, there were a variety of ambiguous and perhaps faulty guidelines for scoring responses that reflected a failure to adequately refine the test. Secondly, while the test measured some aspects of critical thinking, it was neither comprehensive nor thorough. That is, many important areas of critical thinking were not addressed by the test and those that were may not have been thoroughly and accurately assessed. Specifically, we found many questions simply asked students to restate ideas that were provided in the reading material without requiring any significant evaluation or critical analysis. We also found little evidence to corroborate the validity of the test when we examined the correlation between the ETS test scores and other measures of student achievement such as the ACT Test or cumulative grade point average. Finally, ETS informed us that they were removing it from the testing market so it would not be available for further use later that year.

We examined several alternative objective tests that had been developed to evaluate critical thinking. None of these tests involved faculty in the scoring of exams and most of these exams operationally defined critical thinking in a very narrow way. Specifically, the objective tests focus almost exclusively on verbal, categorical, analogical and hypothetical-deductive reasoning. While many faculty members think these skills are important, they also associate the teaching of those formal reasoning skills with courses in logic, mathematics, or formal problem solving. Consequently, the use of such tests as an assessment tool does not encourage broad faculty involvement in the development of critical thinking skills.

In order to encourage faculty involvement in not only the assessment of critical thinking, but also in the improvement of critical thinking skills, TTU embarked on an ambitious plan of having small groups of faculty work together to identify and develop an assessment tool for measuring critical thinking. The underlying idea was to increase faculty involvement and interest in developing critical thinking by identifying critical thinking skills that they themselves thought were important for their own students. Developing their own tests would give them a vested interest in the outcomes.

This effort began with an attempt to analyze what faculty liked about the previously used ETS exam and what they did not. Although the ETS test had numerous problems, the faculty involved in the first workshop generally thought that this type of test measured something important about students' abilities to evaluate and analyze new information. The fact that the test involved information that the students had never seen before was considered important. The fact that the test required students to analyze and evaluate information and form conclusions was also regarded as important. An additional feature that was deemed important by some faculty members, is that some of the tests asked students to determine what additional information they might need to further evaluate the issue under consideration. These observations became the starting point for developing a new test of critical thinking that would have high face validity and hopefully correlate with other measures of student achievement.

During the 2001-2002 year TTU developed and pilot tested its first critical thinking test. Three groups of faculty worked in teams and as members of a larger group to identify important critical thinking skills and develop questions/materials that would measure those skills. The test relied heavily on essay answers to help assess communication skills (as well as critical thinking skills) and leave opportunities for creative answers to questions that don't always have a single correct response. The essay format also involved faculty in the scoring of exams and helped promoted more interest in improving critical thinking skills. In addition, the test was based on topics that the faculty thought students would find intrinsically interesting. The latter decision derived, in part from observations of some student's unwillingness to seriously participate in the previously administered ETS exam because they found the topics irrelevant to their interests and academic focus. The tests also involved some elements of "dynamic assessment," a procedure whereby students are given opportunities to learn and then use that newly acquired knowledge in new situations. Tests which do not use dynamic assessment measure what a student has already learned and not their potential to master new ideas and content.

Key Areas/Skills Targeted for Assessment

1. Ability to interpret numerical relationships in graphs.
2. Ability to identify inappropriate conclusions and understand the limitations of correlational data.
3. Ability to identify evidence that might support or contradict an hypothesis.
4. Ability to identify new information that is needed to draw conclusions.
5. Ability to separate relevant from irrelevant information when solving a problem.
6. Ability to learn and understand information in an unfamiliar domain.
7. Ability to use elementary mathematics skills in the context of solving a larger real world problem.
8. Ability to draw inferences between separate pieces of information and formulate conclusions.
9. Ability to recognize how new information might change the solution to a problem.
10. Ability to communicate effectively.

The locally developed test (CAT) was administered to a stratified random sample of seniors at TTU. A subset of that sample also took the California Critical Thinking Skills Test (CCTST) to help evaluate criterion validity. The results of that first pilot test were very encouraging. The TTU test had high criterion validity when compared to CCTST scores (r = .645) and ACT (r = .659) scores. In addition, the test appeared to have high face validity and provided a good range of test scores with no ceiling or floor effects and a distribution that was reasonably close to a "normal" distribution.

2002-2003 Year Project Report

Overview

During the current academic year, TTU continued the refinement and testing of the CAT critical thinking test while pursuing activities designed to enhance students' critical thinking skills. It is important to note that all of these activities are part of integrated approach to assess and improve critical thinking skills. For example, our efforts to assess critical thinking involve faculty in the scoring of student exams and help faculty understand the weaknesses of our students. We continue to expand the number of faculty involved in the scoring of exams so that we increase awareness across our faculty of the need to improve students' critical thinking skills. Our efforts to assess critical thinking have also looked at gains made by

students as they progress through their college career and through specific courses. Information gathered from the latter type of testing can help us identify the types of courses that might contribute in a significant way to the improvement of critical thinking skills. Our efforts to improve the face validity of our testing instrument will also serve to expand the interest and concern of faculty about students' critical thinking skills. Of course, some activities have been specifically directed at modifying pedagogy to improve students' critical thinking. We are currently approaching these issues from several different perspectives that are described in more detail below.

Our testing and refinement of the CAT critical thinking skills test had two primary goals this year . One goal was to determine the usefulness of the instrument to measure changes inthinking as students progress through their college studies. We were particularly interested in whether the test could be used to measure gain scores as an index of value added by TTU. The sensitivity of the test to such measurements would also provide further evidence to support its validity. A second goal was to further refine the test and improve its face validity. As more faculty are involved in the scoring we receive more feedback about additional types of critical thinking that should be includedin the test. We continue to refine the test to reflect the thinking of more and more faculty across disciplines at the university. This year, approximately 30 percent of the faculty who participated in the scoring of exams were new participants in the critical thinking initiative.

In addition to the test development activities noted above, TTU also pursued several strategies that were specifically designed to improve the teaching of critical thinking skills at the university. These activities involved the identification of classes that could improve students' critical thinking skills and the involvement of faculty from a variety of disciplines in a workshop to explore methods of improving students' critical thinking and problem solving skills.

The university's efforts to improve critical thinking also involved modifications to its strategic plan. Improving students' critical thinking and problem solving skills requires more active learning methods. To encourage such methods, the universityadopted a new strategic goal to emphasize active learning. Some key components of this goal are described in section V below.

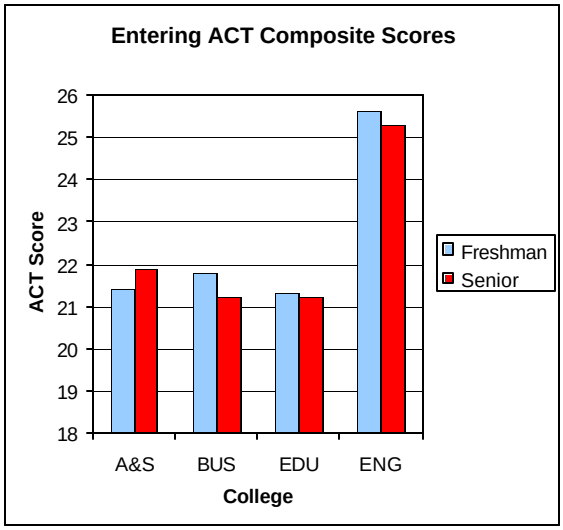
I. Cross-Sectional Study of Students' Critical Thinking Skills

During the Fall Semester of 2002, approximately 100 TTU freshman students were evaluated with the CAT Critical Thinking Test. This is the same critical thinking test that was administered to TTU seniors during the preceding spring semester. This test was reported to have high face validity and high correlations with other measures of critical thinking (CCTST) and academic achievement (ACT).

Sample Characteristics

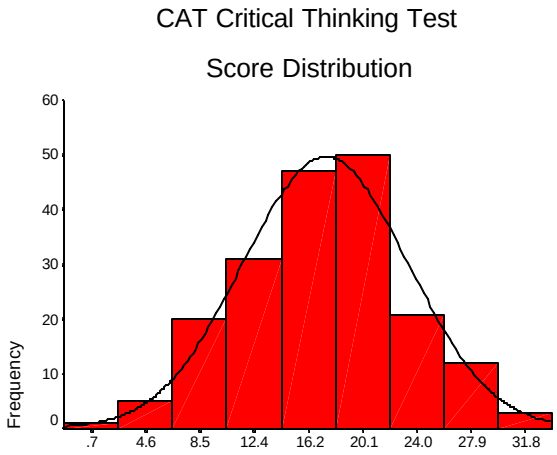
The freshman and senior TTU students were both selected using a stratified random sample from the Colleges of Arts & Sciences, Business, Education, and Engineering. Figure 1 shows the entering composite ACT scores of students in each subgroup within the freshman and senior class and corroborates the equivalence of the freshman and senior samples on ACT scores.

Figure 1



The CAT Critical Thinking Tests were scored by an interdisciplinary group of faculty at TTU. Scoring followed a prescribed set of guidelines for awarding points on each question. Each question was scored by a minimu m of two independent evaluators and by a third evaluator if the first two evaluator's scores differed. Across tests the scores ranged from a low score of 1 to high score of 33 with a mean score of 17.5. The maximum possible score on the test was 39. The distribution of scores is shown in figure 2.

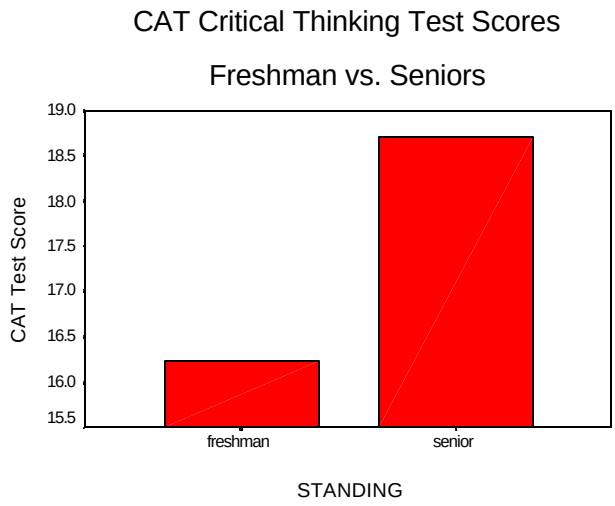
Figure 2



Analysis of Critical Thinking Test Scores

An analysis of covariance was performed on the freshman and senior test scores across the four colleges. Composite ACT score was used as a covariate to adjust for any potential differences between freshman and senior's entering ACT score. The results revealed a significant increase in critical thinking test scores from the freshman to the senior class ($p < .001$). This effect is illustrated in figure 3.

Figure 3



Breakdown by College

Although no significant interaction between college and class standing was found, figures 4 and 5 illustrate the potential gains in critical thinking broken down by college. Figure 4 shows the actual test scores while figure 5 shows scores that have been adjusted to remove the effects of differences in ACT scores across the samples.

Figure 4

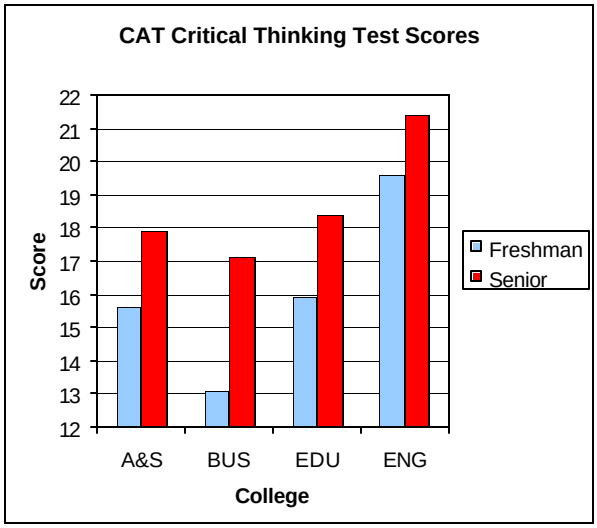
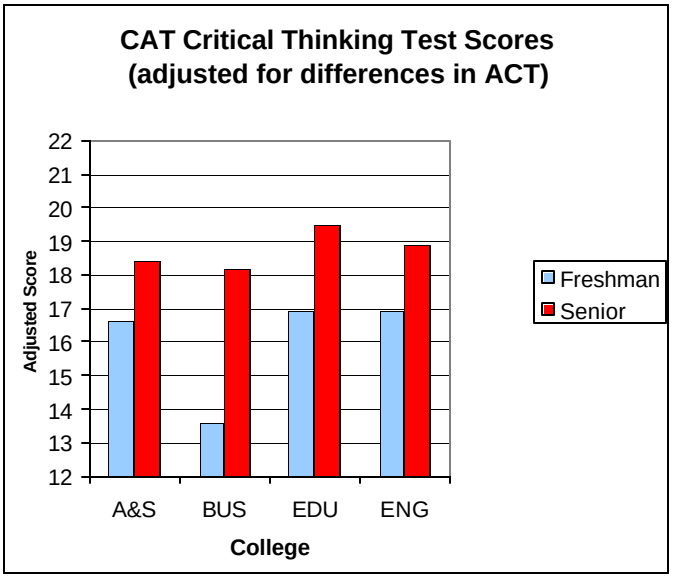

CAT Critical Thinking Test Scores
22
21
20
19
18
17
16
15
14
13
12
Score
A&S
BUS
EDU
ENG
College
Freshman
Senior

Figure 5



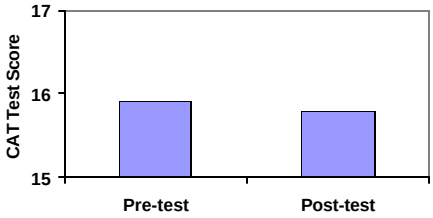
II. Pre-testing and Post-Testing of Specific Courses

The administration of our CAT critical thinking test as a pre-test/post-test in specific courses was undertaken to investigate two issues. First, we wanted to know whether the test was sensitive enough to measure gains that could be achieved by students in a single course. If this is possible we could use the test results to identify courses or methods of instruction that would be representative of best practices in encouraging students to develop critical thinking skills. Second, assuming a course does not improve critical thinking skills, we wanted to know how reliable the test is when taken twice at two different times. To evaluate these issues, we administered the test in two different courses in the social sciences with the consent of the instructors. Both courses were junior level classes. Students in both courses took the pre-test during the first two weeks of the course and then took the post-test during the last week of classes. The pre-tests and the post-tests were scored by the same group of faculty from a broad spectrum of disciplines.

Course #1

Sixteen students in this class took both the pre-test and post-test. No significant change was observed in the performance of students between the pre-test and the post-test. A test-retest reliability coefficient = 0.6, $p < .01$. Overall test performance was remarkably similar on the pre-test and the post-test in this course.

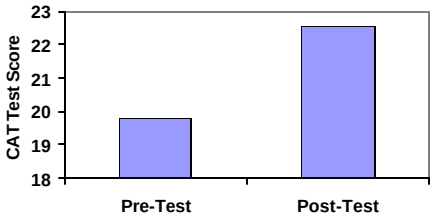
Course #1



Course #2

Nineteen students in this class took both the pre-test and post-test. A significant improvement ($p < .05$) was observed between scores on the post-test and scores on the pre-test for students in this course.

Course #2



The results of the pre-test/post-test evaluations of two courses indicate that the CAT Critical Thinking Test may be sensitive enough to detect the positive effects of an individual course on a student's critical thinking and problem solving skills. These findings suggest that test could be used to identify courses and pedagogies that promote critical thinking and problem solving skills. The findings don't indicate how prevalent such courses may be across a university curriculum. The findings also indicate that test performance can be reasonably stable over time particularly when looking at group means.

III. Efforts to Improve Face Validity of the CAT Critical Thinking Test

In each new round of test scoring, new faculty are added as scorers to expand the base of participating faculty and to provide new input about the face validity of the instrument. The number of new faculty included in each round of scoring represents about 20 - 30 % of the total number of faculty participating in the scoring at any one time. We try to preserve continuity between scoring sessions to allow valid and reliable comparisons of results from one scoring session to another. On the other hand, we try to include new faculty in the process to encourage broader faculty involvement in the process and to continually assess ways to improve the face validity of the evolving test.

During the scoring sessions we solicit faculty feedback about things that may need to be added to the test to provide a better assessment of students' critical thinking. As a result of this input, several faculty

members helped develop new items that might increase the face validity of the instrument. Each of these items was pilot tested on a small sample of students to evaluate the question and possible scoring guidelines. Twelve new questions were produced through this process. The new items required a mixture of short answer essay responses and some objective responses. These new items assessed students' ability to critically evaluate information on topics ranging from advertising claims to tests of scientific theories. The results reported below are based on the administration and scoring of test that combined these new items with the existing questions on the CAT Critical Thinking Test developed by TTU.

Faculty Evaluation of New Test Items

An interdisciplinary team of 11 faculty members was selected to evaluate and score an expanded version of the TTU CAT Critical Thinking Test. The test was administered to a stratified random sample of approximately 100 seniors from education, arts & sciences, business, and engineering disciplines. Faculty who participated in the scoring of these tests were also asked to complete a survey that evaluated each item's contribution to the face validity of the test. An analysis of the survey responses suggested six of the twelve new items would increase the face validity of the test if they were added to the existing test. These items were examined further in the analysis reported below.

Effect of New Items on Criterion Validity

The stratified random sample of students who completed the new expanded version of the CAT Critical Thinking Test also completed the CCTST so that we could evaluate the effects of the new questions on criterion validity using another critical thinking skills test. In addition, we examined the relationship between test performance and ACT scores as another index of criterion validity. We focused our attention on the six new items that were judged to increase the face validity of the CAT Critical Thinking Test.

The results of a multiple regression analysis revealed that adding the six new questions to the CAT Critical Thinking Test improved the overall correlation with the CCTST test score significantly ($p < .05$) and explained an additional four percent of the variability in CCTST score performance. A similar analysis of ACT scores indicated that adding the six new questions to the CAT Critical Thinking Test improved the overall correlation of the test with ACT scores significantly ($p < .01$) and explained an additional 6 percent of the variability in ACT score performance. These analyses indicate that the six additional questions that faculty members selected to improve the face validity of our test also improved the criterion validity of the test when compared to CCTST and ACT scores.

During the scoring session we also solicited faculty input about the possibility of deleting questions from the original CAT Critical Thinking Test that were either redundant with other test items or that had questionable effects on the face validity of the test. Three items were subsequently identified for possible deletion. We analyzed the effects of deleting these items on the criterion validity of the test using multiple regression analyses. Removing the three designated items did not significantly affect the correlation with the CCTST. A similar analysis of ACT scores indicated that removing the three designated questions from the revised CAT Critical Thinking Test improved the overall correlation of the test with ACT scores significantly ($p < .05$) and explained an additional three percent of the variability in ACT score performance. These analyses suggest there would be no negative consequences of deleting the three items from the test and that the deletion could even improve criterion validity relative to ACT test performance. We will strongly consider this option if only to help simplify the administration and scoring of the test.

IV. Workshop to Improve the Teaching of Critical Thinking Skills

TTU conducted a faculty development workshop to explore and share ideas for improving students' critical thinking. This workshop involved a broad spectrum of disciplines (arts & sciences, business, education, and engineering) across the university and included individuals whose classes have received high student IDEA evaluations for progress on *learning to analyze and critically evaluate ideas*, or progress on *learning to apply course material to improve thinking, problem solving, and decisions*. The workshop also included faculty who participated in the pre-test/post-test administration of the CAT Critical

Thinking Test, and faculty who simply wanted to learn more about how to improve students' critical thinking.

The workshop provided an overview of the efforts that the university community has engaged in to develop authentic assessments of critical thinking based on faculty input, but focused mainly on a discussion of the types of learning experiences that could help develop critical thinking skills. A variety of active learning pedagogies were discussed that have been used successfully by faculty in different disciplines. The discussion considered both the positive impact of these active learning strategies on students as well as the drawbacks and potential pitfalls that some have experienced when using these alternative methods of instruction.

The discussion was engaging and stimulating for the faculty. To evaluate the effects of the workshop an anonymous survey was administered to the participants after the workshop. The results are summarized below.

	Yes	**No**
Did the workshop stimulate discussion of critical thinking?	100%	0
Were you exposed to any new ideas for improving students' critical thinking?	86%	14%
Were you exposed to ideas in the workshop that you could adapt to your own classes?	79%	21%
Are you willing to modify your approach to teaching to enhance student's critical thinking skills?	100%	0
Would you like to attend future workshops that explore ways to enhance students' critical thinking skills?	100%	0

This workshop was successful in stimulating discussion about ways to enhance critical thinking and exposing faculty to ideas for improving students' critical thinking. The workshop alsohelped initiate informal collaborative mentoring between faculty members. Future workshops will be designed to better help faculty adapt active learning methodologies to their own courses.

V. Other Efforts to Encourage Active Learning Strategies

In addition to the four specific initiatives described above, TTU also sought to encourage more active learning strategies in course instruction through a new strategic goal for the university. This goal emphasizes three types of active learning that allundergraduates should the opportunity to experience.

- Provide all undergraduates opportunities to participate in original research.
- Provide all undergraduates opportunities to participate in service learning.
- Provide all undergraduates opportunities to develop teamwork skills.

The matrix below identifies the relevant skills that each type of active learning in this new university goal could help improve and that are being assessed by our critical thinking test.

Type of Active Learning	Underlying Critical Thinking Skills
Original Research	Critical thinking, Problem solving, Communication Skills
Service Learning	Critical thinking, Problem solving, Communication Skills
Projects Involving Teamwork	Problem solving, Communication Skills

Even though this is a new university goal, eight units/departments across the university have already developed specific strategic plans to help the university meet this goal in the past seven months. We anticipate that this new university goal will be addressed by many more academic units in the future.

Dissemination of findings and involvement of new faculty

One key component of the strategic plan for evaluating and improving critical thinking at TTU is strong faculty involvement in the process. Thus our strategy has included a variety of efforts to disseminate our findings to the faculty and to encourage the involvement of additional faculty. A website has been established to disseminate information and solicit faculty involvement. Email has been used to notify all faculty members of our efforts and to solicit additional involvement. In addition, we have encouraged deans and department heads to discuss this critical thinking initiative and encourage participation. We are encouraging faculty involvement in several specific ways including participating in the scoring of exams, participating in workshops to improve the teaching of critical thinking, and the participating in the development of new test questions to assess critical thinking. Faculty members also receive extra compensation for their participation in these activities and this has helped create persistent interest in this initiative.

Our plan for dissemination also includes efforts to engage other universities in the evaluation and refinement of this assessment instrument. During this coming year we are scheduled to present information about this project in a concurrent session at the annual meeting of the Southern Association of Colleges (SACS).

Summary of current year

TTU continued its efforts to develop a faculty centered test of critical thinking. Faculty continue to play a major role in developing test questions and evaluating what questions to include in the test. We consider this type of faculty involvement crucial for continuing efforts to increase the face validity of the assessment instrument. We continue to refine the test with the goal of increasing face validity and criterion validity. Continued faculty involvement in the scoring of these tests also serves to engage faculty and help them understand the need to improve our students' critical thinking skills. During the current year we were able to compare the performance of freshmen students to the performance of seniors on our test. Seniors showed significantly higher scores than freshman even when we controlled for academic ability (as indexed by ACT scores). The latter results provide evidence that TTU is effectively contributing to the improvement of critical thinking skills. However, it also shows us that we could be doing more to improve critical thinking skills. We have also used the CAT Test of Critical Thinking Skills to measure gains in specific courses. Successful methods for engaging students in activities that promote critical thinking were identified using the latter approach and were shared with other faculty at a university workshop. That workshop brought together faculty from diverse disciplines to share and explore ideas for improving the development of critical thinking skills in our students. Faculty evaluations of that workshop were very positive and also pointed out the need for more specific mentoring to help faculty incorporate new pedagogy into their courses. Our strategic plan outlined below includes workshops specifically designed to help faculty improve the development of critical thinking skills in their courses.

These results support the idea that an effective method of assessing and improving the teaching of critical thinking at the university is to develop assessment instruments with considerable faculty input. This will insure that faculty have a vested interest in outcome measures and that they will be inclined to adjust their teaching methods to improve performance. In addition, efforts were undertaken to disseminate the results of these efforts to the whole faculty at TTU and to encourage the broader participation of faculty in this critical thinking initiative. The current year's work sets the stage for further refinement of our assessment tool, dissemination of this instrument to other institutions, and continued efforts to improve critical thinking at TTU.

Overview of the Five Year Plan

2003 – 2004

1. **Continue to seek faculty input about the face validity of our critical thinking test and explore modifications that might improve the face validity of the test.**
    - Continuing to improve the face validity of the test will increase faculty acceptance of the test results and their willingness to use teaching methods that can help develop critical thinking skills.
2. **Continue to administer the test in conjunction with other measures of critical thinking and academic performance to improve the criterion validity of the test when compared to other instruments.**
    - Increases confidence that the test is measuring what it is intended to measure.
3. **Continue to hold faculty workshops to score the tests.**
    - Faculty involvement in the scoring will help faculty understand the deficiencies in critical thinking.
    - Involves more faculty in test development and gives them a vested interest in the assessment outcomes.
4. **Establish a mentoring program that would use small group workshops to help interested faculty incorporate active learning strategies designed to improve critical thinking skills in their courses.**
    - Assessments alone cannot improve critical thinking. These workshops will help faculty explore specific methods for improving the development of critical thinking skills in their own classes.
    - The workshops will pair faculty who have successfully used active learning strategies with new faculty who are interested in developing critical thinking skills in their courses.
5. **Explore methods for disseminating the test to other universities.**
    - Making the test available to other institutions will permit us to compare our performance to other institutions.
    - Making the test available to other institutions will allow us to gather information that we can use to make additional improvements to the test.
6. **Encourage the use of more active learning experiences that could foster the development of critical thinking skills.**
    - Research indicates that active learning strategies can encourage the type of student involvement in the learning process that underlies critical thinking.

2004 - 2005

During the subsequent year of this five year cycle, TTU plans to continue the activities described in the 2003-2004 year plan with certain modifications. We plan to assess the effectiveness of each component in our plan outlined above and take action to make improvements where needed. For example, our analysis may indicate that we need to make further adjustments in the critical thinking assessment instrument we have developed.

We will also be evaluating the effectiveness of our mentoring activities and efforts to infuse critical thinking into the curriculum. These assessments will include a variety of measures such as faculty feedback, analysis of student teaching evaluations, and an analysis of pretest/posttest critical thinking scores in individually targeted classes. We will also be tracking the progress we are making in improving critical thinking by continuing to collect and analyze critical thinking in our students. The latter data will help us understand where progress is being made and where efforts need to be targeted.

We will also be building upon the experience of faculty that are participating in the program by encouraging these faculty to share with their colleagues innovative ideas for enhancing critical thinking. These efforts will be supported in various ways. First, we believe that faculty participation in the development of assessment tools will empower faculty and give them a vested

interest in making improvements. Secondly, we plan to continue to provide financial incentives for faculty to participate in these important activities.

We observe that there are many faculty members who recognize student deficiencies in the area of critical thinking but lack the tools, expertise, and incentives to do anything about it. Our underlying goal is to create an environment where there are tools to measure the kinds of critical thinking that faculty value, expertise to help faculty engage in effective methods of developing those critical thinking skills, and finally financial rewards to encourage their participation.

Key Components of the continuing plan

1. Continue to involve faculty in scoring workshops to both encourage their interest in improving students' critical thinking and to get feedback on the face validity of our test.
2. Continue to explore effective mentoring strategies for preparing new and existing faculty to improve students' critical thinking.
3. Continue to support the development of new questions and improvements to the test to assess critical thinking using faculty input.
4. Continue to validate the test against other measures of critical thinking and academic achievement
5. Continue to disseminate the results and encourage additional faculty and department involvement.
6. Explore collaboration with other universities to use and evaluate our critical thinking test to further enhance its development and value.